



# INFORMATION TECHNOLOGY DIVISION



Providing Technology For The Future Command Center

Aug 4, 2003



# Mission/Vision Statement: Information Technology Division IFT



The mission of the Information Technology Division is to conduct broad-based R&D in information technologies to support the Information Directorate thrusts of Global Awareness, Dynamic Planning and Execution, and Global Information Enterprise. The division advances the state-of-the-art in the sciences and technologies pertinent to these thrusts that are not commercially available or mature enough for combat systems.

Vision: Dominant Information Technology in the hands of the warfighter.



# Information Technology Division AFRL/IFT



**Information Technology (IFT)**  
**315-330-3011**

**Embedded Information Systems  
Engineering  
(IFTA)**  
**937-255-6548 x 3609**

- Affordable Embedded Information System Design and Development
- Adaptive/Reconfigurable/Scaleable Information Systems
- Assured Performance of Complex Information Systems
- Advanced Embedded Information System Concepts  
(Wright Research Site)

**Information Awareness &  
Understanding  
(IFTB)**  
**315-330-3528**

- Knowledge Base Technologies
  - Link Discovery
  - Total Information Awareness (TIA)
  - Bio-Surveillance
  - Theater Ballistic Missile (TBM) Reasoner
  - Command Post of the Future
- Dynamic Assembly for Systems Adaptability, Dependability, and Assurance (DASADA)
  - Fuselets for the Joint Battlespace Infosphere
  - Network-centric Infrastructure for Command, Control and Intelligence (NICCI)
- Intelligent Agent Based Systems
  - Autonomous Negotiating Teams (ANTs)
  - DAML
- Active Templates
- Formal Methods
- Software Affordability

**Advanced Computing  
Technology (IFTC)**  
**315-330-2983**

- Agile Architectures
  - Mission Aware Processing
  - Distributed Information Systems
  - Embedded Architectures
- Command and Control Innovations on HPC
  - Force Structure Simulation
  - Hyperspectral Framework
  - Numerical Model Integration
  - HPC to the Field
- Novel Information Processing Paradigms
  - Bio-Molecular Computing
  - Quantum Information Processing
  - Nano-Technology
  - MEMS-Based PicoSatellite Inspector

# Mission/Vision Statement: Embedded Information Systems Engineering Branch IFTA



**Mission:** Develop, demonstrate, and transition embedded information system technologies which enable command and control (C2) of both current and next-generation aerospace weapon systems to ensure global information dominance and air and space superiority. Provide key hardware and software technologies for affordable, adaptable, assured, and advanced embedded information systems.

**Vision:** Information dominance enabled by affordable, adaptable, assured, and advanced embedded information system hardware and software technologies.



# **EMBEDDED INFORMATION SYSTEM ENGINEERING (IFTA)**

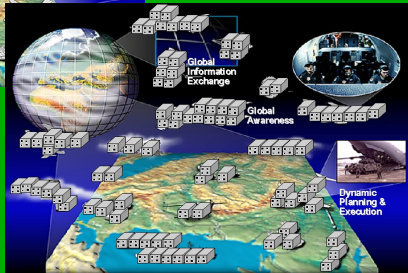


**937-255-6548 x3609**

- **Affordable Embedded Information System Design and Development**
  - **Adaptive/Reconfigurable/Scaleable Information Systems**
  - **Assured Performance of Complex Information Systems**
  - **Advanced Embedded Information System Concepts**
- (Wright Research Site)**



# Embedded Information Systems Engineering Branch (AFRL/IFTA) Mission, Thrust and Sub-Thrusts



Millions of Signal and Data Processors  
Billions of Lines of Software  
Fusion of Trillions of Bits of Information  
to the Knowledge Level

Operating  
Systems

Application  
Software

Firmware



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Embedded  
Information  
Systems

Knowledge  
Exchange

Embedded  
Systems



Boards



FPGAs

## Core Technologies

Embedded  
Information  
System  
Modernization

Space-Based  
Embedded  
Computing &  
Design  
Technologies

Advanced  
Computing  
Techniques

Reconfigurable  
and Adaptive  
Embedded  
Computing

Information  
Assurance

Real-Time

**Mission:**  
Develop, demonstrate, and  
transition timely embedded  
information system  
technologies that enable  
command & control of current

**Affordable**  
Information Systems  
Design/Development

Technologies for  
affordably designing and  
developing state-of-the-  
art hardware and/or  
software for highly-  
complex, time-critical,  
global information  
systems

**Adaptive/Reconfigurable**  
Information Systems

Technologies for rapidly  
enhancing hardware  
and/or software  
information systems to  
incorporate new features  
or dynamically adapt to  
changing environments  
and missions

**Assured**  
Performance of  
Complex Information  
Systems

Technologies for  
verifying, validating, and  
assuring the functionality  
and integrity of complex  
information systems  
operating in a system of  
systems environment

**Advanced**  
Embedded  
Information System  
Concepts

Technologies to support  
the future integration  
and interoperability  
requirements of  
manned/unmanned  
tactical weapon systems  
within the Global  
Information Grid

Thrust: Embedded Information Systems



# Embedded Information Systems Engineering Branch

## AFRL/IFTA

DSN 785-6548  
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### THRUST AREA

### SUB-THRUST AREAS

### CORE TECHNOLOGIES

### PROGRAMS

**Embedded  
Information  
Systems**

**Affordable  
Embedded  
Information  
System Design  
and Development**

**Adaptive/  
Reconfigurable/  
Scaleable  
Information  
Systems**

**Assured Performance  
of Complex  
Information Systems**

**Advanced  
Embedded  
Information  
System Concepts**

**Embedded Information Systems  
Modernization**

**Space-Based Embedded Computing  
and Design Technologies**

**Embedded Information  
Technologies for Unmanned and  
Autonomous Systems**

**Advanced Computing  
Technologies**

**Reconfigurable and Adaptive  
Embedded Computing**

**Information Assurance for  
Embedded Systems**

**Real-Time Adaptive Middleware**

**Incremental Upgrade of Legacy  
Systems (IULS) Technology Demonstration  
(C-17, CV-22)**

**Insertion of Embedded Infosphere Support  
Technologies (IEIST)**

**Unmanned Combat Air Vehicle (UCAV)  
(Mission Control System Lead)**

**Weapon System Open Architecture  
(WSOA)**

**Power Aware Computing and  
Communications (PAC/C)**

**Mission-Specific Processing  
(MSP)**

**Embedded Information System Assurance  
(EISA)**

**Bio-Computing**



# Affordable Embedded Information System Design and Development Embedded Information Systems Modernization



Technical  
Maturity



JOVIAL to C  
Re-engineering

Real-Time  
Fault-Tolerant  
Middleware

Embedded  
Computer  
Emulation for  
F-16

Automated  
Wrapper  
Generation

Embedded  
Computer  
Emulation  
for C2  
Systems

Initial Legacy  
System  
Connectors  
for C2  
Systems

Computer  
Emulation  
Demo for B-2

Incremental  
Upgrade Tech  
Demo for CV-  
22

Incremental  
Upgrade Tech  
Demo for C-17

Real-Time,  
Legacy  
System  
Connectors  
for Embedded  
Systems

Affordable  
Insertion of  
Infosphere  
Support  
Technology

**Rapid,  
Affordable  
Modernization  
of  
Embedded  
Systems**



FY0  
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FY0  
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7



# Adaptive/Reconfigurable/Scaleable Embedded Information Systems

Technical  
Maturity



Adaptive  
Command and  
Control

Mission Specific  
Processing

Software  
Programmable  
Radio

Image/Video  
Compression

Polymorphic, Multi-  
Mission Reactive  
Architectures

Large-Scale Networked  
Embedded Information  
Systems Design and  
Control

Power Aware  
Computing  
Systems

Reconfigurable  
Computing Hardware  
and Software



**Multi-Mission,  
Reactive,  
Low-Power  
Computing for  
Adaptive  
C4ISR**

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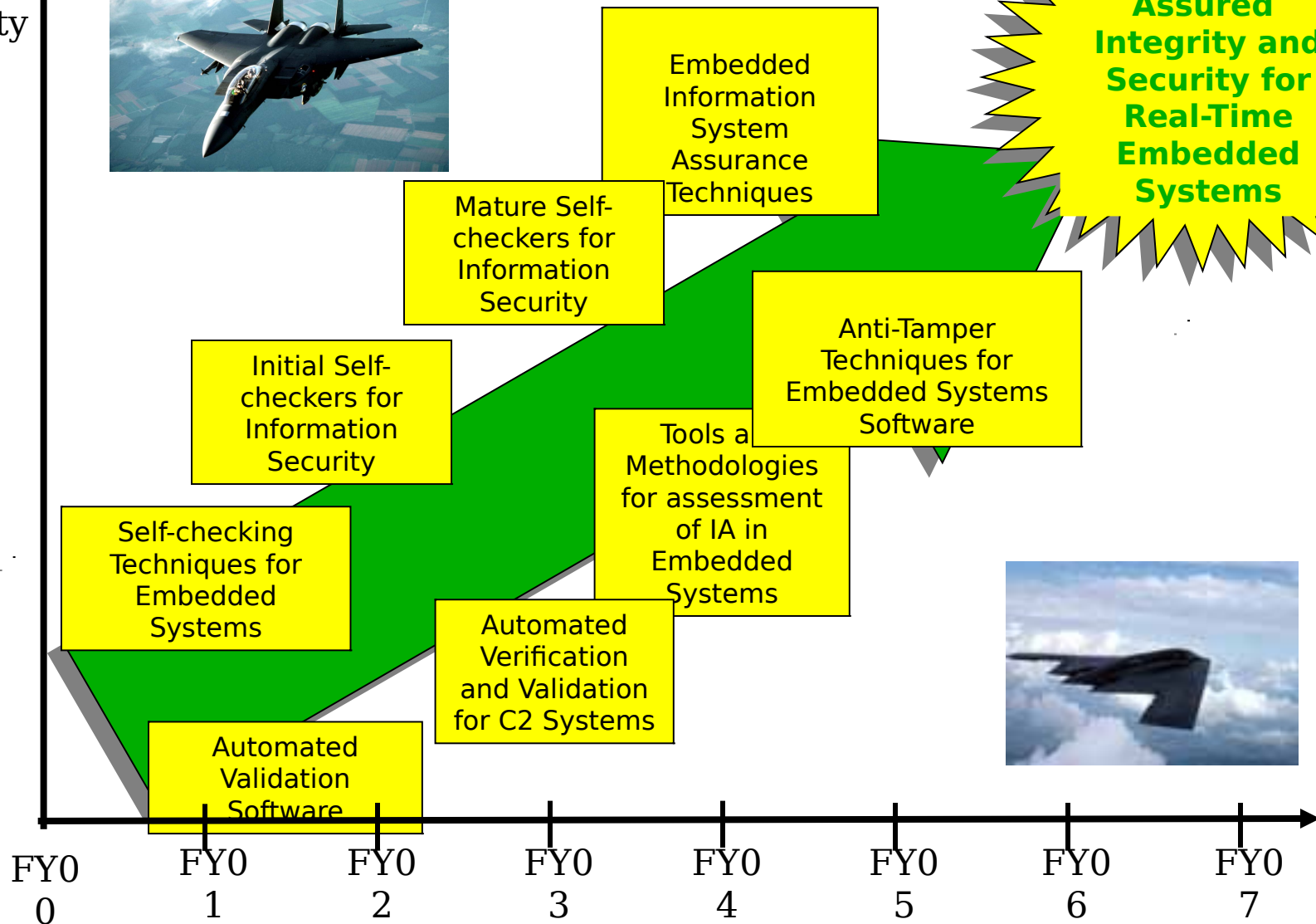
# Assured Performance Of Complex Information Systems



Technical  
Maturity

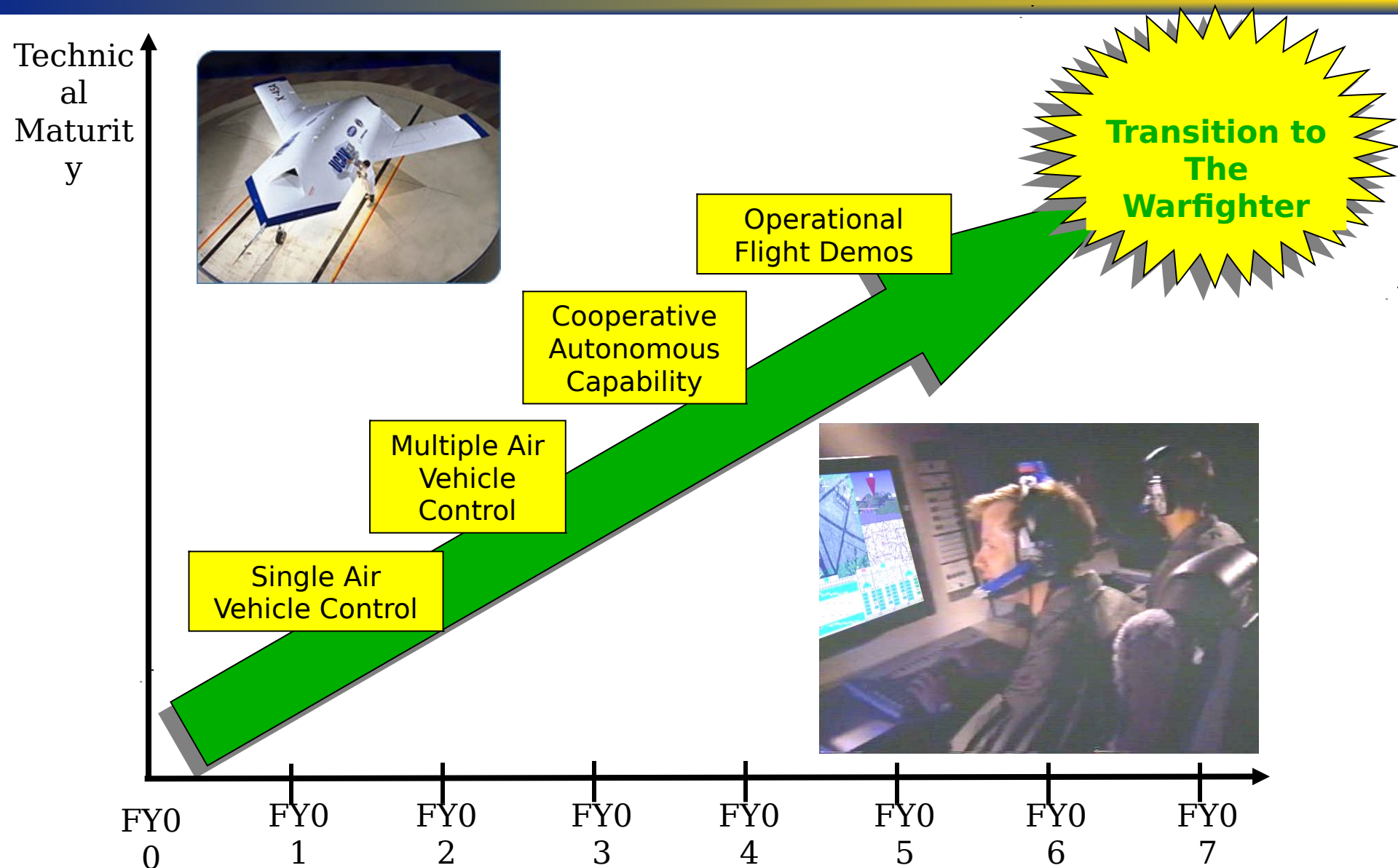


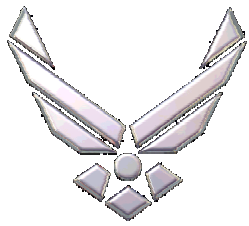
**Assured  
Integrity and  
Security for  
Real-Time  
Embedded  
Systems**





# Advanced Embedded Information Systems Concepts Unmanned Combat Air Vehicle Mission Control System (MCS)





# Mission/Vision Statement: Information Awareness and Understanding Branch IFTB



**Mission:** Performing leading-edge research and development of technologies to enable the realization of computationally intelligent systems for information understanding, predictive situational awareness, and dynamic decision making.

**Vision:** Unleash the power of computational intelligence to provide enhanced situational awareness and understanding to the warfighter.



# Information Awareness & Understanding (IFTB)



**(315) 330-3528**

- Knowledge Base Technologies
  - Link Discovery
  - Terrorist Modus Operandi Detection System (TMODS)/Intelligent Mining Platform for the Analysis of Counter Terrorism (IMPACT)
  - Total Information Awareness (TIA)
  - Bio-Surveillance
  - Theater Ballistic Missile (TBM) Reasoner
  - High Quality Interactive Question and Answering (HITIQA)
  - Command Post of the Future
- Dynamic Assembly for Systems Adaptability, Dependability, and Assurance (DASADA)
  - Fuselets for the Joint Battlespace Infosphere
  - Network-centric Infrastructure for Command, Control and Intelligence (NICCI)
- Intelligent Agent Based Systems
  - Autonomous Negotiating Teams (ANTs)
  - DARPA Agent Markup Language (DAML)
- Active Templates
- Formal Methods
- Software Affordability



# Knowledge Base Technology Objective/Goal

## Computational Intelligence

## "Data to Decisions"

## Decision Support

Provide enabling technology to support a combat information management system where users are provided with tailored information products and displays that support their functional responsibilities.

### Technology Focus Areas

- Repository Generation
- Repository Access
- Repository Management

Ontologies  
Relationships  
Behaviors  
Rules

Experience  
Judgement  
Understanding

Facts  
Timelines  
Patterns  
Packages

Flat Files  
Documents  
Web pages  
Data Tables

Structure  
d  
Unstructu

**Relevant Data**  
**"Ascending the Cognitive Hierarchy"**  
**Information**  
**Knowledge**

**DATA**

1997

2000

2002

2005

2008



# Dynamic Assembly for Systems Adaptability, Dependability, and Assurance (DASADA)



*Vision: Perpetual System Operation & Evolution*

**Gauges & Mechanisms  
for On-the-fly System  
Assembly/Re-assembly**



**Run-time Monitoring and  
Reassembly Infrastructure**

**Component Frameworks  
Composition & Analysis**

**ADL Toolkits and  
Interchange Protocols**

**Architecture Description Languages**

**Component Frameworks  
Analysis & Characterization**

**System Architecture  
Descriptions  
Gauge/Constraint  
Specifications**

**Composition Gauges  
Execution Monitoring &  
Measurement Probes  
Simulation**

**Wrapper Code  
Generation**

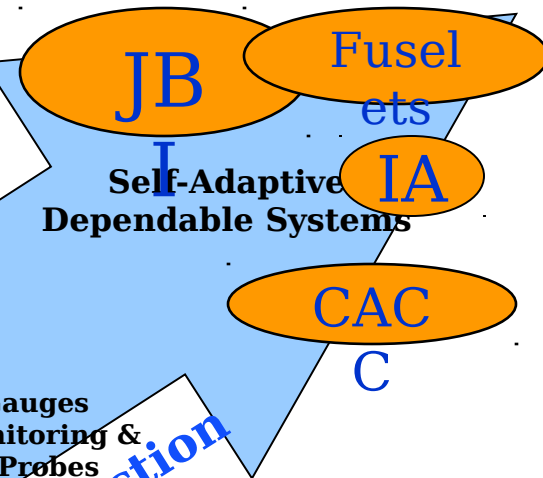
**Feedback  
Mechanisms**

**Legacy, COTS/GOTS  
Components &  
Component Libraries  
Composability  
Indicators**

**Compositional  
Simulations**

## **Support Capabilities**

- » ADL Toolkits and Interchange Protocols
- » Run-time Monitoring Probes
- » Specification Carrying Code and Gauges
- » Legacy System Wrapper



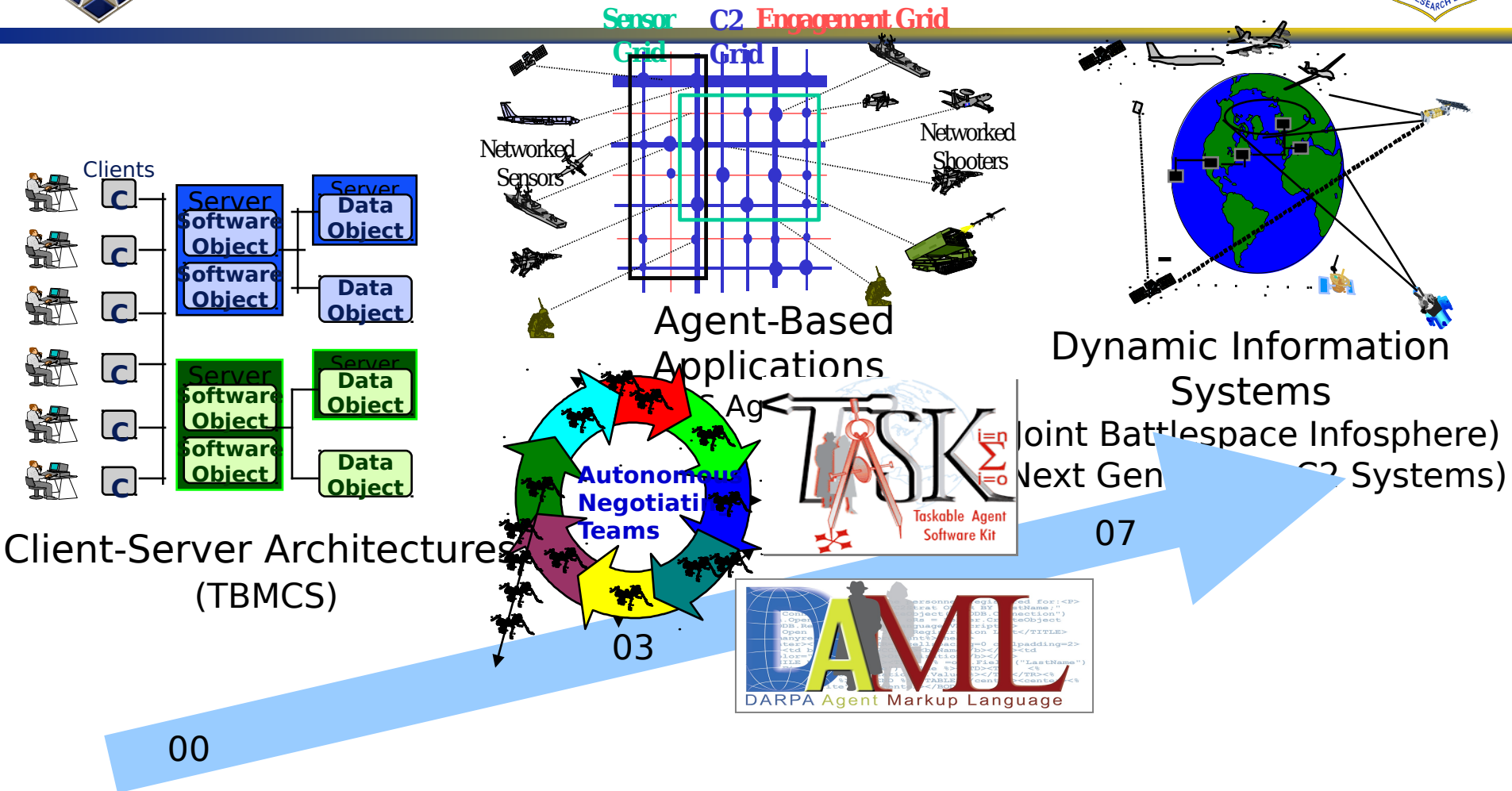
2000

2002

2004



# Intelligent Agent Based Systems



**Technology to support large-scale dynamic multi-agent systems**  
**Expertise to apply that technology to AF C4ISR applications**



# Active Templates

## Dynamic Spreadsheets for Planning & Execution



### Problem

- Current planning systems not reactive enough to handle real-world execution in near real time
- Lack of planning tools that can be defined & maintained by military staff
- Special Operations Forces (SOF) need lightweight, domain specific planning tools:
  - Crisis response plans quickly become complex, constrained
  - Data gathering/briefing time vs core planning decisions
  - Causal dependencies can be critical

#### Key Research Areas

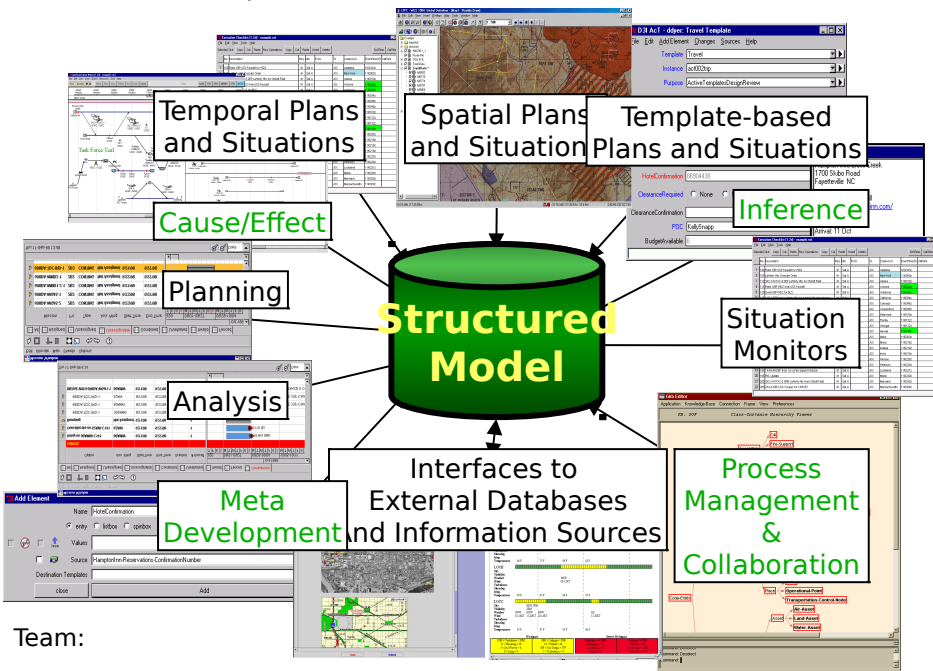
- Automatic & Manual Template Tailoring
- Light-weight Template Architectures, Template Merging
- Inferencing & Constraint-based Reasoning
- Case-based Template Retrieval & Linking
- Simple, Adaptable Grammars & Template Modeling Languages

#### Technical Approach

- Capture Essential Information About **How** to Do Something
  - Standard Operating Procedures - Encoded As a Spreadsheet
  - Enumerated Choices, Decisions, Constraints, Rationale
- Linkage to Real-time Data Feeds & Sensor Info
- Rapid, iterative development with operational users

#### Results

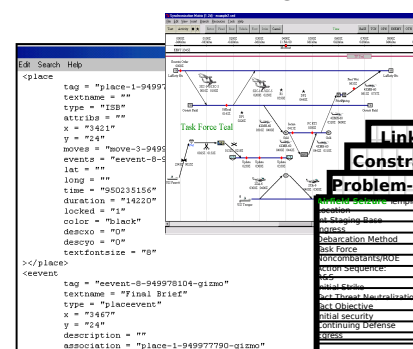
- SOFTools transitioned to SOCOM for inventory and support
- Automatic data feeds to SOF Target Intelligence Packages
- Spatial Planning Tools now part of SOF C2 Centers
- Initial Guidance Plans in <12 hrs vs 2 days



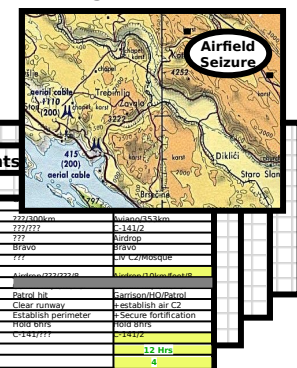
Team:

- Industry: ALPHATECH, BBN, GITI, ISX, Rockwell, SoftPro
- Academia: CMU, SRI, U MD, UMASS, USC
- DoD: AFRL, DARPA, NRL, SOCOM

### TEMPORAL VIEW



### SPATIAL VIEW



### PLAN STORAGE

### TEMPLATE VIEW



# FORMAL METHODS

## Problem:

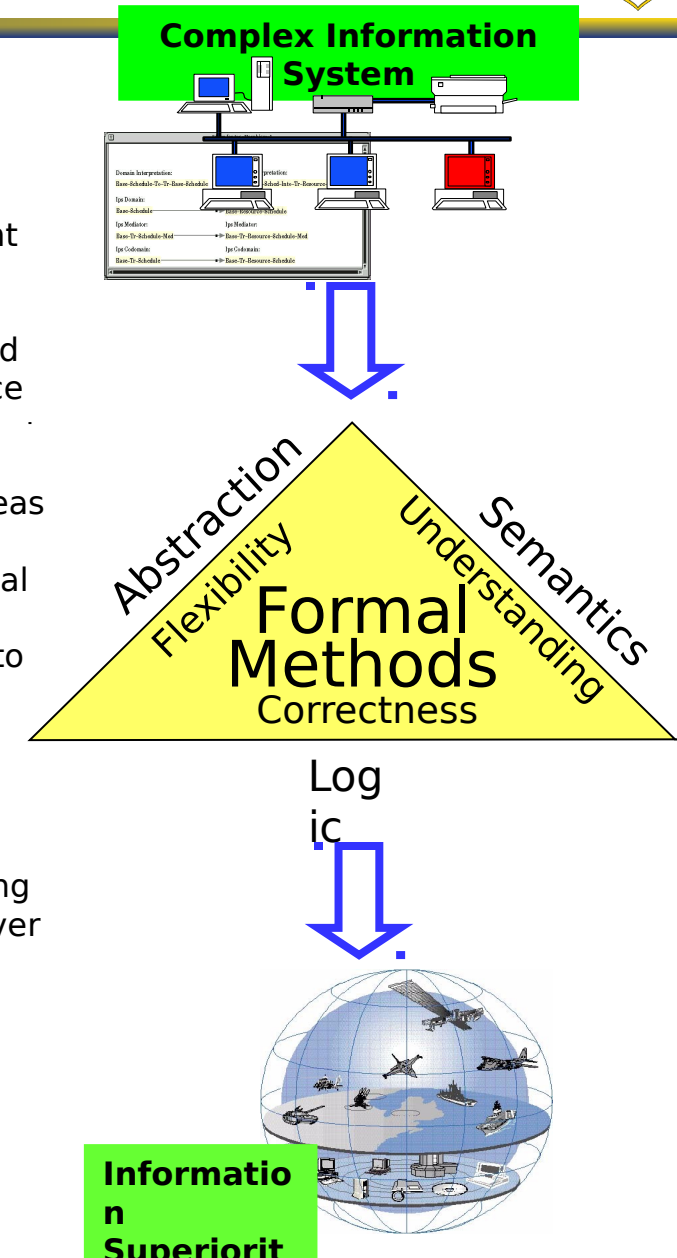
- Complex systems are difficult to understand, design and construct so that they work as expected at all times.
- Many of the systems and tools that aid in the development of highly assured systems cannot be combined casually without possibly introducing inconsistencies.
- The design and development process is not adequately and sufficiently supported by tools that help raise the assurance of the system.

## Approach:

- Use formal methods, which are based on mathematical areas that help manage complexity.
- Evaluate and exploit the most flexible, versatile and general formal systems and tools.
- Evaluate, exploit and develop formal tools that are easier to use and better integrated into the life cycle of the system.
- Develop new and better models and tools for the construction of secure, adaptable and highly assured systems.

## Uniqueness:

- The symbiotic combination of formal methods and emerging technologies will provide more powerful solutions to the ever increasing demands on information systems.

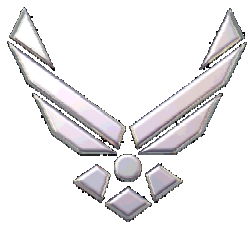




# Software Affordability

“Affordability of Software-Intensive Systems aims to provide the best value among available solution alternatives. Achieving software affordability relies upon the use of best software acquisition, management, and development practices and processes to maximize both functional (e.g., algorithm computation & display of result) and non-functional (e.g., reliability) properties within life cycle budget and schedule constraints”

***An AFRL/IF Interpretation Of Software Affordability***



# Mission/Vision Statement: Advanced Computing Technology IFTC



**Mission:** Research, develop, demonstrate and transition advanced computing technology to enable intelligent systems and deliver new capabilities for air and space applications.

**Vision:** Information dominance through computational innovations.



# **Advanced Computing Technology Branch: AFRL/IFTC**



**315-330-  
2983**

- **Agile Architectures**
  - **Mission Aware Computing**
  - **Distributed Information Systems**
  - **Embedded Architectures**
- **Command and Control Innovations on HPC**
  - **Force Structure Simulation**
  - **Hyperspectral Framework**
  - **Numerical Model Integration**
  - **HPC to the Field**
- **Novel Information Processing Paradigms**
  - **Bio-Molecular Computing**
  - **Quantum Information Processing**
  - **Nanotechnology**
  - **MEPSI**



# Advanced Computing Technology

## Thrusts/Technologies/Programs

### THRUSTS

### TECHNOLOGIES

### PROGRAMS

## Advanced Computing Technology

### Agile Architectures

### Command And Control Innovations On HPC

### Novel Information Processing Paradigms

### Embedded Information System Architectures

### Space-Based Embedded Computing

### Advanced Computing Technologies

### Reconfigurable, Adaptive and Embedded Computing

### High Performance Computing

### Distributed Computing

### Force Structure Simulation

### Modeling & Simulation Science

### Quantum Information Processing

### Bio-Molecular Computing

### High Performance Embedded Computing Software Initiative

### Space Based Radar Embedded Processing

### Power Aware Computing/Communication

### Polymorphous Computing Architectures

### Data Intensive Systems

### High Productivity Computing Systems

### Scalable Parallel Processing for Joint Experimentation

### Distributed Information Enterprise Management System

### Joint Battlespace Infosphere Simulation

### Hyperspectral Framework

### Organically Assured and Survivable Information Systems

### Scenario Generation

### Quantum Information Science and Technology

### MEMS-Based PicoSatellite Inspector

### Simulation of Bio-Molecular Microsystems

### Bio-Computation



# Agile Architectures Thrust



**Challenge:** Information Superiority - Ability to Rapidly Collect, *Process, Disseminate* and Protect Information While Denying These Capabilities to Our Adversaries.

## Approach

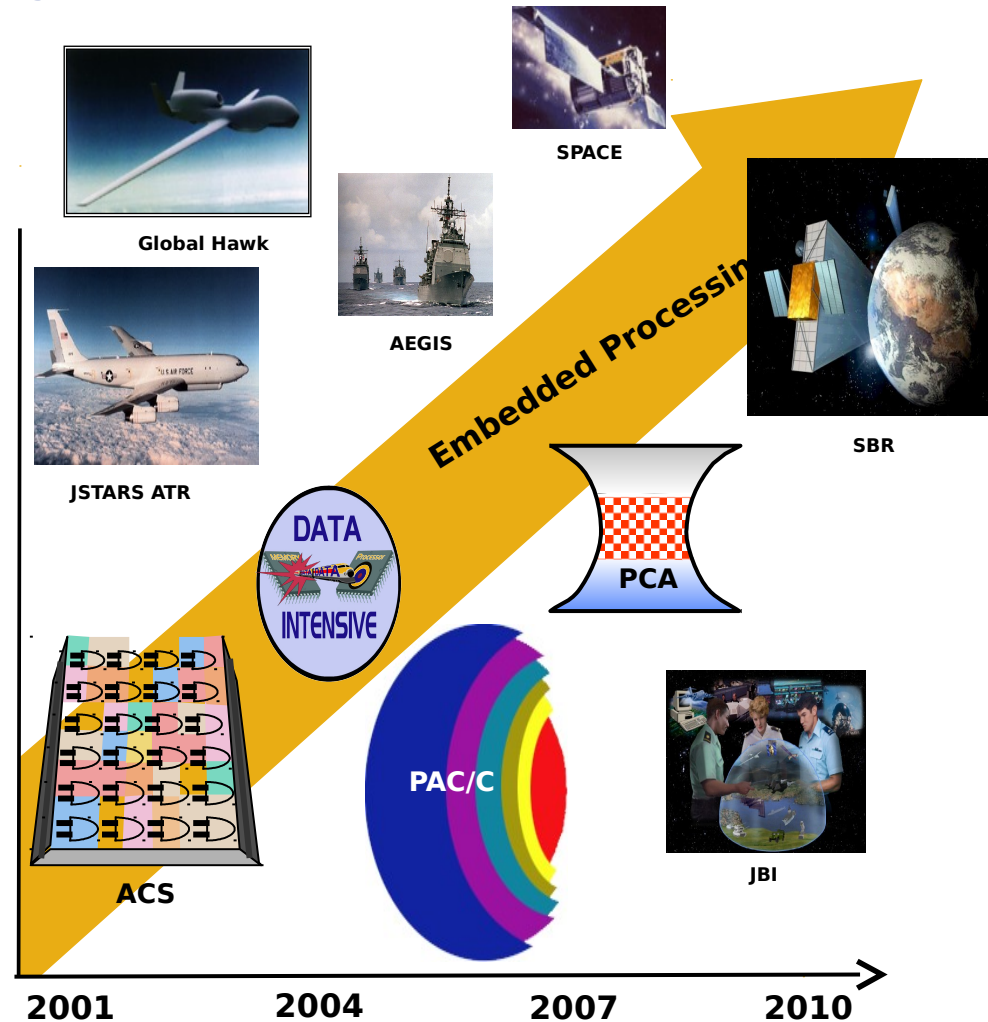
- Develop Novel Computing Architectures that Increase the Ability to Process and Disseminate the Voluminous Amounts of Information
- Modeling and Simulation of Distributed Information Enterprise Systems
- Develop Affordable, Scalable Computing Architecture Solutions Applicable to the Individual Processor through the Global Computational Grid
- Integrate Low Power and Reconfigurable Architectural Techniques

## Potential Users

- Any System with Embedded Computing needs Requiring Power Awareness and Mission Configurability

## Users

- Missile Defense Agency, Space Based



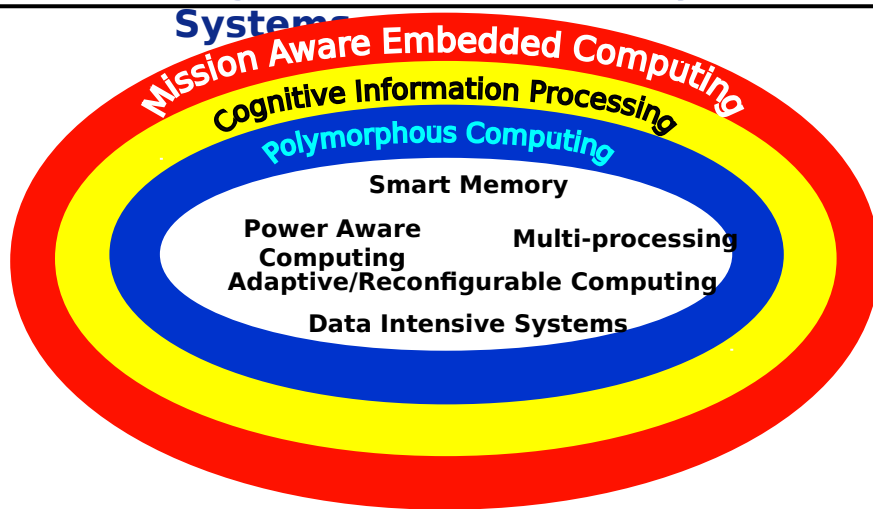


# Mission Aware Computing

## Agile Architectures Thrust



**Objective: Integrate Emerging Embedded Processing Architectures with Advanced Cognitive Information Systems Research to Enable Mission Aware Processing Systems**



### Impact

- Optimized Information Allocation
- Improved Performance as Knowledge and Experience Increases
- Cognizant of Its Own Behavior and Comprehend Its Own Capabilities
- Improved Observe, Orient, Decide, Act Loop
- Real Time Reconfigurable Architectures
- Process Vast Amounts of Information for Improved Decision Making

Status - TRL4

### Approach

- Leverage Commercial, DARPA, DoD and Other R&D Investments In Emerging Processing Architectures
- Merge Cognitive Functions Such as Perception, Reasoning, Intuition and Knowledge
- Exploit Information Systems to Demonstrate Affordable, High Performance, Fault Tolerant, Low Power and Weight, Mission Aware System Architectures

- SADL
- FY03
- FY04
- FY05



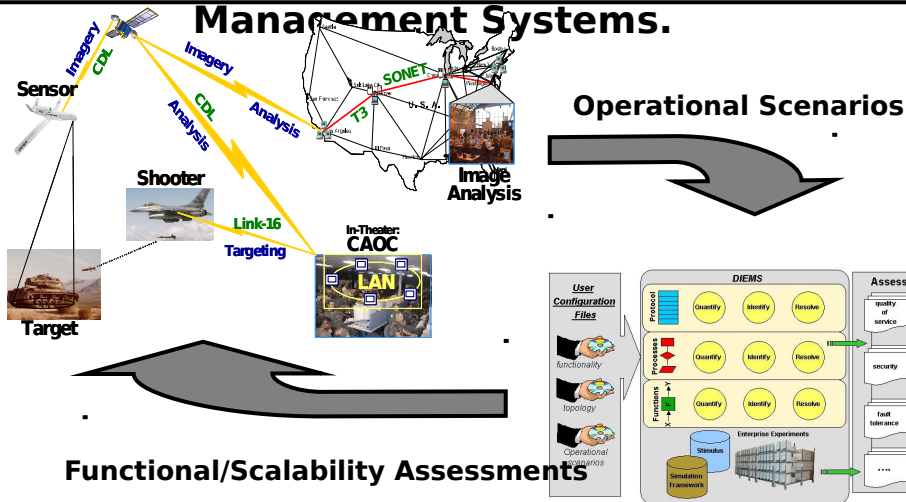
# Distributed Information Systems

## Agile Architectures Thrust



**Objective:** Establish High Performance Enterprise-Modeling Framework to Assess and Influence the Development and Deployment of DoD Distributed Information

### Management Systems.



### Impact

- Assess Key Information Enterprise Protocols, Processes and Common Core Functions
- Identify and Mitigate Programmatic Risk Early Within the Information Systems Architecture Development
- Model Key Resources to Identify, Quantify and Resolve Topology Issues
- Provide Analytical Means to Assess Scalability Issues

### Approach

- Address Broad Variety of Operational Information Enterprises
  - Localized Infrastructure → Globally Distributed
- Address Enterprises Composed of Tens of Thousands of Platforms
- Address deployment aspects : security, quality of service, fault tolerance, etc.

### Status - TRL3

- Joint Battlespace Infoshere Baseline
- FY03
- FY04
- FY05

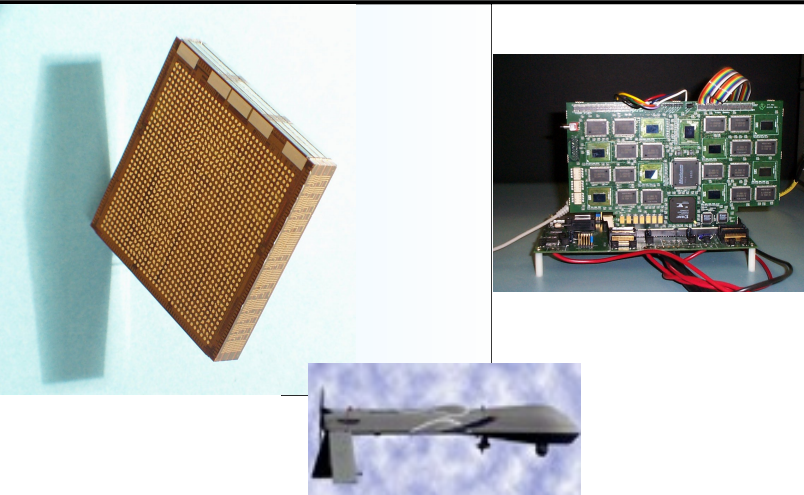


# Embedded Architectures

## *Agile Architectures Thrust*



**Objective:** Advance the SOA for Embedded High Performance Computers.



### Impact

- Requirement for Embedded HPC
- Allows advanced systems
  - Discriminating interceptors
  - On-board processing for SBR
- Scalable platform for power efficient processors and Re-configurable processors

### Approach

- Develop low power HPCs integrating power efficient processors and Field Programmable Gate Arrays (FPGAs)
- Leverage Commercial Components and Processing to the extent possible
- Joint programs with AFRL/VSSE to ensure compatibility with future space vehicles
- Base software on open source code allowing reuse of the code and greatly reducing development time and risk

### Status - TRL6

- 96 processor embedded HPC demo
- 250K lines of real-time code
- <3Kg with thermal control



# Command and Control Innovations on HPC Thrust



**Challenge: Decision Superiority - Conversion of Voluminous Information from a Multitude of Sources into Superior Knowledge.**

## Approach

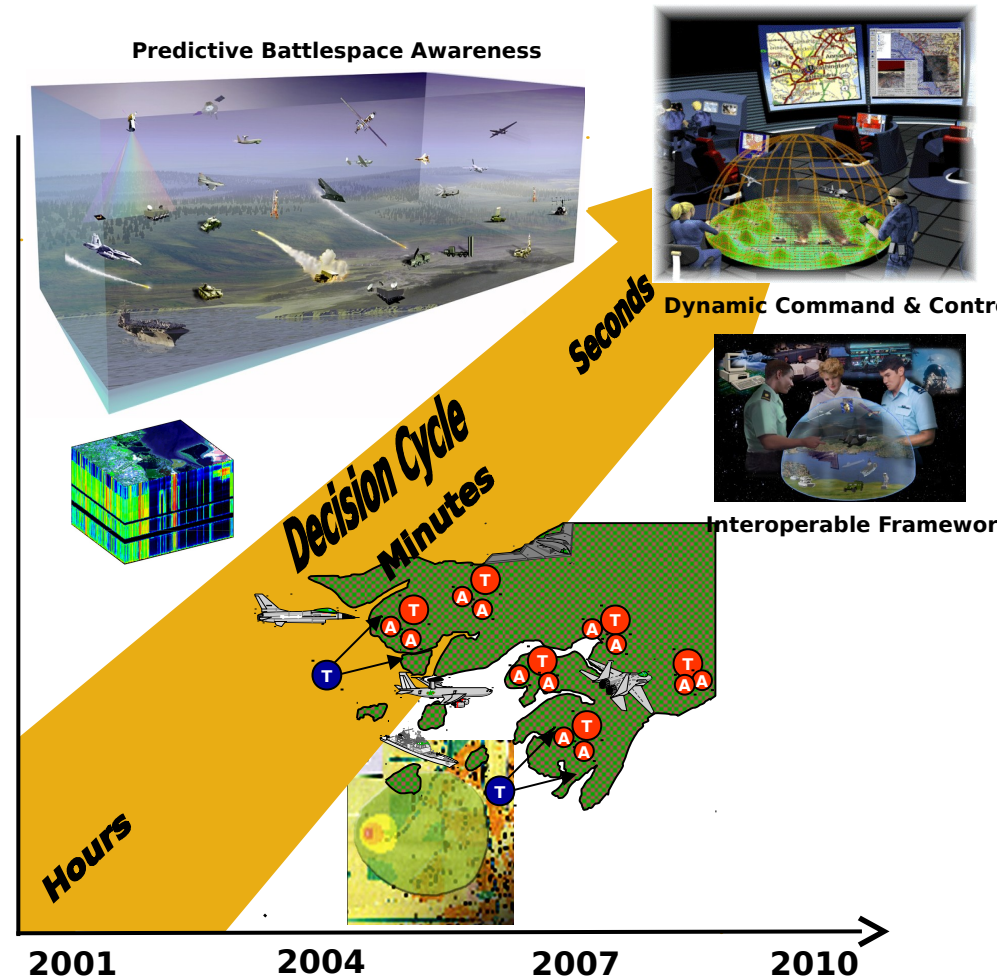
- Develop Interoperable Frameworks for Real-Time Command & Control
- Develop Force Structure Simulation Capability to Provide Realistic Simulated Combat Behaviors to Exercise Developing R&D Programs as well as for Course of Action Analysis
- Integrate C2ISR Technologies with Simulation Frameworks for Predictive Battle Management and Improved Operator Situational Awareness
- Field High Performance Computers to Rapidly Process Information Into Superior Knowledge for Warfighter Real-Time Decision Support

## Potential Users

- C2 Battle Planners and Decision Makers Who Need Tailored, Accurate, Real-Time Situational Knowledge

## Collaborators

- EBO, JBI, JFCOM/J9, HPCMO, AF Wargaming Institute



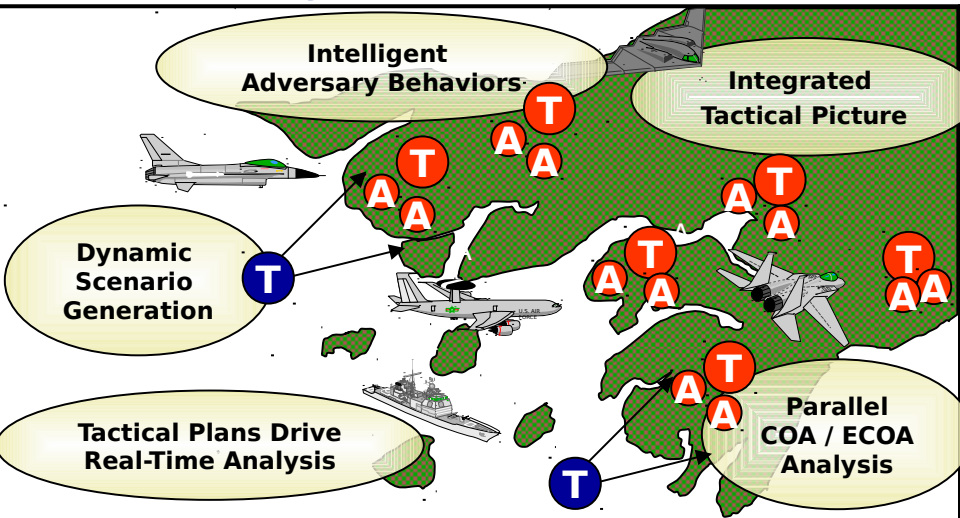


# Force Structure Simulation

## Command and Control Innovations on HPC Thrust



**Objective: Develop Simulation Technology to Perform Assessment and Course-of-Action Analysis of Predictive Battlespace Environment**



### Impact

- Predictive Assessment of Adversarial Actions
- COA Strategy and Objective Assessment Providing Multiple Alternatives on Demand to Commander
- Force Structure Simulation Concepts to Integrate C2ISR Technologies for Real-time Decision Support

### Approach

- Use High Performance Computing for Rapid Assessment of Concurrent Scenarios
- Develop Adversary Modeling for Predictive Enemy Course-of-Action (ECO) Behavior
- Develop Techniques to Automate Scenario Transformation and Generation From Tactical Picture

### Status - TRL3

- SAB Demonstration
- FY03 Tactical Plans Drive Real-Time Analysis
- FY03 Dynamic Scenario Generation
- FY05 Parallel Course of Action Analysis
- FY07 Integrated Tactical Picture
- FY08 Intelligent Adversary Behavior



# Hyperspectral Framework

## *Command and Control Innovations on HPC Thrust*



**Objective: Develop a Scalable, Portable, High Performance Computing Software Framework for Rapidly Accessing and Processing Hyperspectral Data.**



### Impact

- Near Real-Time Access to Hyperspectral Imagery Data for Battlespace Awareness
- Imagery Products for Intelligence Analysts and Battlefield Decision Makers
- Increased Capability to Accurately Locate the Enemy and Precisely Attack Key Enemy Forces or Capabilities
- Accurate and Fast Battle Damage Assessment

### Approach

- Leverage Serial DoD Hyperspectral Imagery Codes
- Use DoD HPC to Rapidly Process Raw Hyperspectral Data to Produce Imagery Products
- Develop Module for Broadsword to Provide Rapid Query of Hyperspectral Data for the ISR Community
- Provide Client for JBI to Provide Rapid Publish and Subscribe for Command & Control
- Plug and Play Architecture for

### Status - TRL5

- Integration and Test of 6 Hyperspectral Codes within the Framework
- Broadsword Demonstration on SKY and Beowulf Platforms
- 1Q FY03 NIMA Demonstration
- 2Q FY03 Port to Additional HPC
- 2Q FY03 JBI Core Services Demonstration

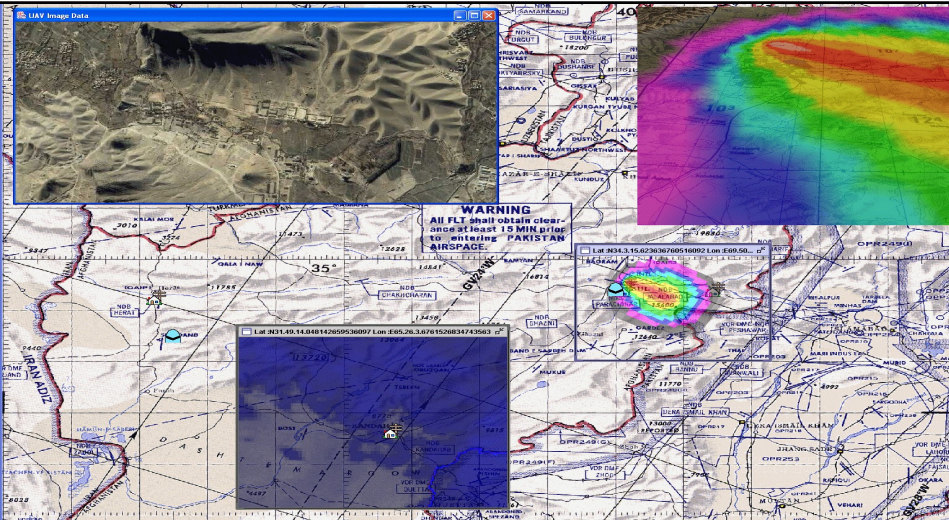


# Numerical Model Integration

## Command and Control Innovations on HPC Thrust



**Objective: Real-Time Modeling for Dynamic Planning and Execution.**



### Approach

- **Assimilate simulation information with field observations**
- **Evaluate goodness of fit based on divergence of simulation and observations**
- **Use of High Performance Computing for Rapid Access to Weather Information**
- **Provide Client for JBI to Provide Rapid Publish and Subscribe for Command and Control**

### Impact

- **Near Real-Time Access to Tailored Weather Information for Battlespace Awareness**
- **Imagery Products for Intelligence Analysts and Battlefield Decision Makers**
- **Improved Operator Situational Awareness and Predictive Battlespace Awareness through Timely Access of Weather Data**

### Status - TRL2

- **Demonstrated WxSpaces Using JavaSpaces**
- **FY03 Environmental Data Cube Connected to Joint Battlespace Infosphere (MM5 model)**
- **FY03 Develop Space Based Programming Repository**
- **FY04 Sensor data expert system**
- **Goodness of model expert system**
- **FY05 Expert system for Wx information extraction**
- **FY06 JBI agent based client**

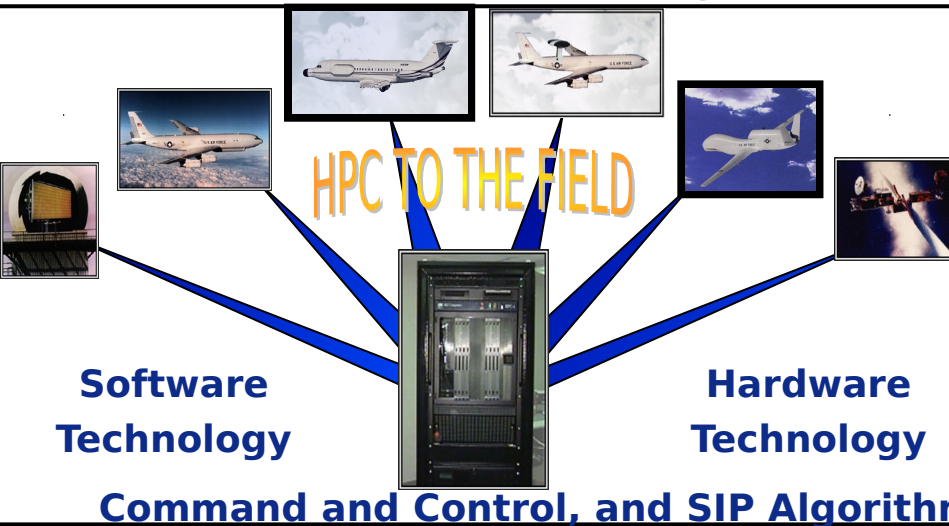


# HPC to the Field

## Command and Control Innovations on HPC Thrust



**Objective: Develop Innovative HPC Capabilities for the DoD Community for Remote Access and Field Deployment**



### Impact

- Increased Computing Capability for Rapidly Processing Information into Superior Knowledge for Warfighter Real-Time Decision Support
- Low Cost, Advanced Computing Technologies Available for Remote Use and Field Deployment
- Advanced Computing Power and Reconfigurability for Dynamic Air and Space Support

### Approach

- Leverage HPCMO and Commercial Investments in Computer Technology
- Address Increased Compute Requirements within the Scientific Community
- Develop Deployable HPC Assets Available to the Entire DoD Community
- Maintain a Code Repository Available for DoD Reuse

- New Computational Paradigms through Computational Innovations
- 5 Chassis SKY Embedded HPC Deployed 3 Times to DoD End Users
- 2Q FY03 Dual Rack Heterogeneous Cluster On-Line for Community Use
- FY04 Next Proposal Cycle



# Novel Information Processing Paradigms Thrust



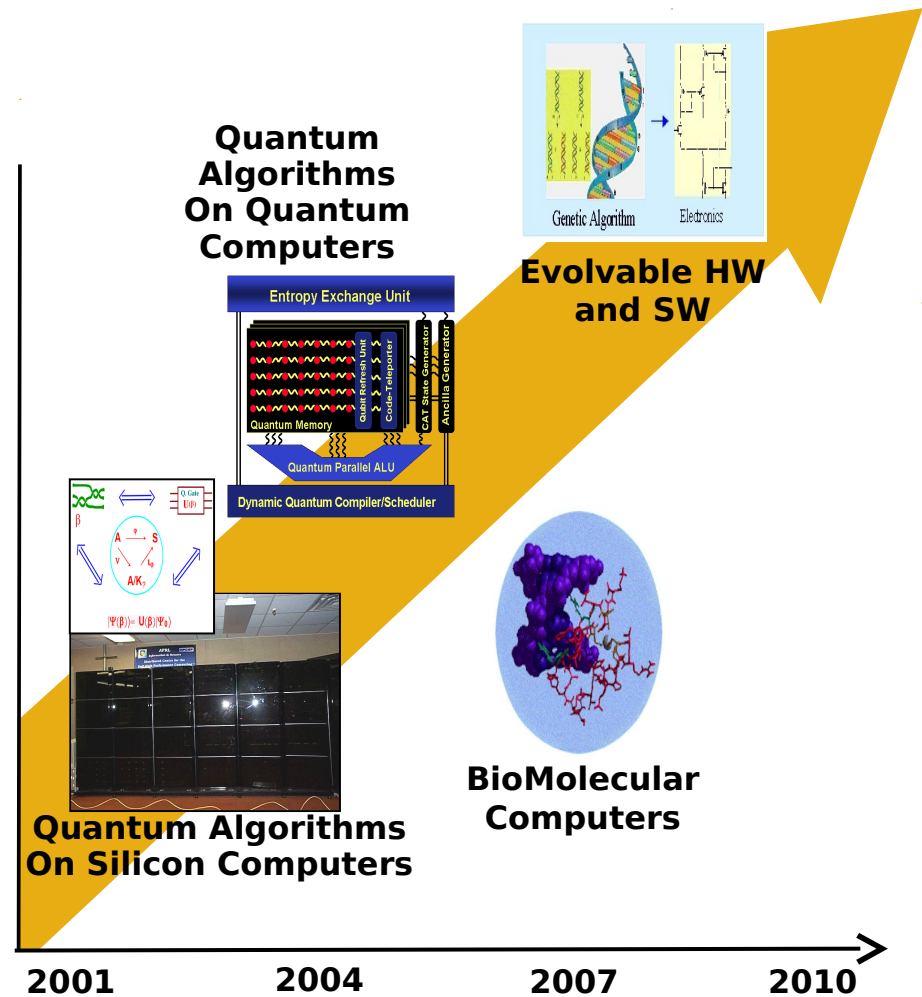
**Challenge:** Determine the Applicability of Revolutionary Technologies to Impact Information and Decision Superiority.

## Approach

- Explore Novel Methodologies for Understanding Large Quantities of Information (Collect, Store, Process and Disseminate)
- Utilize Advanced Modeling and Simulation Techniques to Rapidly Define the Impact of these Methodologies on Information Systems
- Establish Examples to Reveal Technology Potential
- Establish Measurable Metrics to Evaluate these Novel Methodologies
- Develop Architectures and Algorithms to Exploit New Computational Paradigms for Command and Control Applications

## Collaborators

UC-Berkeley (Whaley), MIT (Chuang), NYU (Mishra), Syracuse (Stuart), Aerospace Corp., JPL, and Space Battle Lab



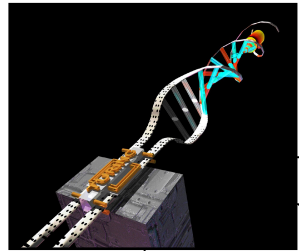


# Bio-Molecular Computing

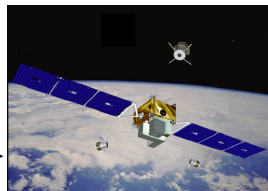
## *Novel Information Processing Paradigms Thrust*



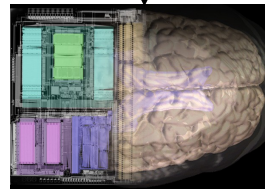
**Objective: Exploit Inherent Computational Capability of Biological Systems to Produce Revolutionary Levels of C4ISR**



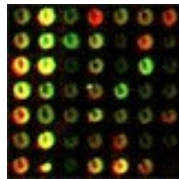
**Self Assembled,  
Low Power,  
Adaptive  
Hybrid Systems**



**Autonomous Small  
Platforms**



**High  
Performance  
Human-  
Computer  
Interfaces For  
C4ISR**



**Interfaces To Sensors**

### **Approach**

- Develop High Level Architectures
- Develop CAD Tools for Hybrid Systems, Micro-biofluidics
- Computation Models: Assess for Optimal Information Processing, Scalability, Interfaces
- Advance High Performance Bio-Memory
- Explore High Bandwidth Human-Computer Interfaces

### **Impact**

- Orders of Magnitude Increase in Resolution of Battlefield Awareness
- Revolutionary Levels of Battlefield Autonomy
- Orders of Reduction In Communications Bandwidth Demand for Sensor Network
- Ability to Operate and Survive in Harsh Environments
- Orders of Magnitude Reduction in Power Draw per Compute Operation

### **Status - TRL2**

- DARPA BioSpice V1.1/SIMBIOSYS, Progress in integration of programs
- Computation Models, assessment of viability done, modeling optimization of information exchange format begun
- Bio-Memory, NYS funding for new project on integration of media and I/O
- Significant progress towards building a new community of researchers in BMC

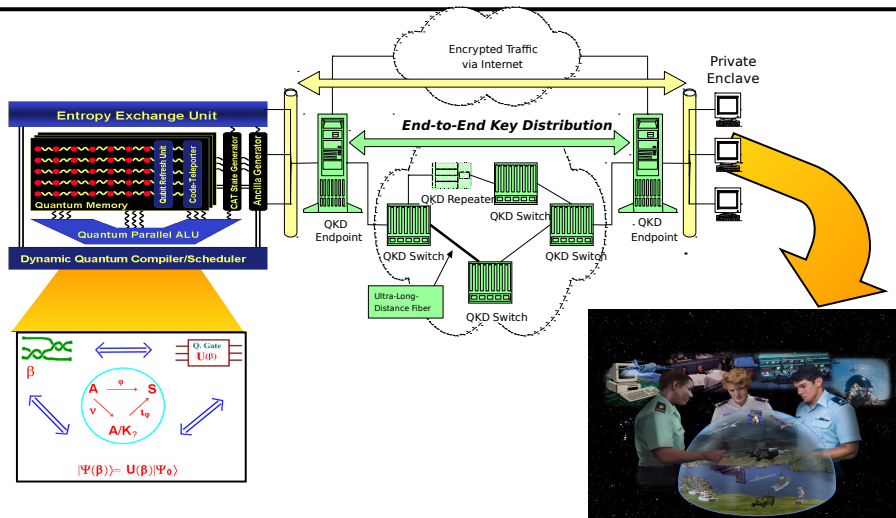


# Quantum Information Processing



## Novel Information Processing Paradigms Thrust

**Objective: Apply Quantum Information Science to Revolutionize Information Dominance.**



### Impact

- Rapid Image Processing
- Rapid Optimization of Logistics
- Secure Distributed Simulation and Computation
- Rapid Scenario Simulation
- Accurate, Protected, & Assured Information
- High Bandwidth Communications
- Massively Parallel Computation

### Approach

- Understand, Control, and Exploit Quantum Mechanical Phenomena for Exponential Increases in Information Processing Capacity
- Leverage Quantum Computing Research in Algorithms and Architectures for:
  - Secure Distributed and Local Computing
  - Information Exploitation
  - Intractable Information Processing Tasks such as Scheduling & Resource Optimization

### Status - TRL2

- Secure Remote Computation

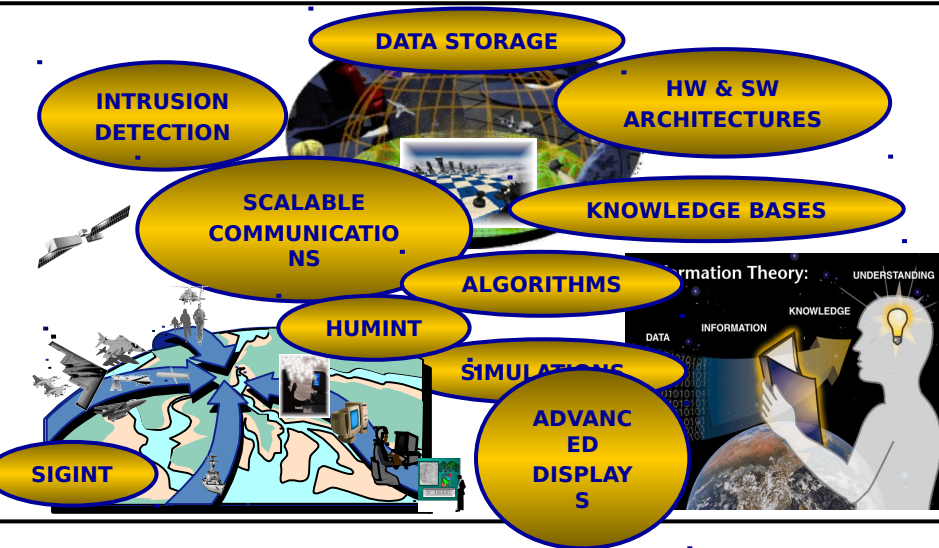


# Nanotechnology

## *Novel Information Processing Paradigms Thrust*



**Objective: Exploit Properties of Nanotechnology to Revolutionize Information Dominance.**



### Approach

- Creation of Integrated Systems through Control of Matter on the Nanometer Length Scale
- Design Tools for Nano-Bio-Info Systems
- Simulation, Analysis & Characterization of Atomically Controlled Materials and Structures
- Exploitation of the Electronic, Optical, Magnetic, Chemical, Biological and Mechanical Phenomena and Properties Dominant at  $<100$  nm Scale

### Impact

- Revolutionary Computing Architectures for Information Dominance
- Decision Aides Approaching Human Intelligence
- Distributed, Interactive C2 Simulation and Visualization
- Distributed and Networked Sensing, Fast, Sensitive Chem/Bio-Threat Detection
- Autonomous Space Operations, Dynamic Stealth

### Status - TRL2

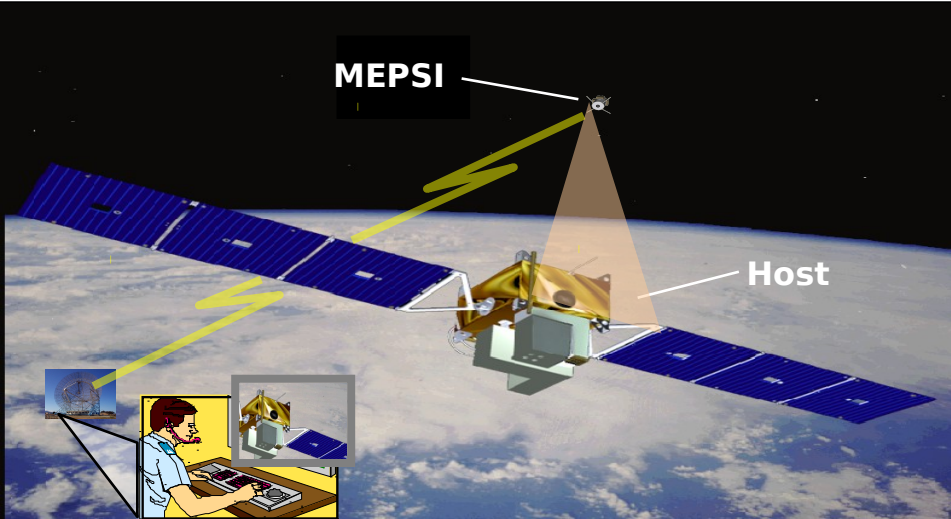


# MEMS-based PICOSAT Inspector



## *Novel Information Processing Paradigms Thrust*

**Objective: Enable Radical New, Low Power, Autonomous, On-Board Decision Making Architectures in Support of On-Demand Situational Awareness and Asset**



### Impact

- Low-Cost, Dynamic Information Systems
- Novel Space Information Architectures
- Protection of DoD Space Assets
- Active On-Board Rapid-Response Threat Protection Capability for Decision Makers (Autonomous Threat Warning/Attack Reporting)
- Provide Autonomous On-Board Anomaly Detection and Resolution for Launch and C2 Operations

### Approach

- Demonstrate Feasibility of Implementing Task Oriented On-Board Hardware Agents
- Leverage state-of-the-art MEMS Subsystems for Communications, Data Storage, Propulsion, Power Generation, Imaging, Ranging, Navigation, Attitude Control, and Processing
- Infuse Intelligent Decision Making Capabilities
- Demonstrate a Direct Application Scenario for Knowledge Based - Intelligent Systems

### Status - TRL7

- Successfully completed two pre-flights:
  - FY 00 JAWSAT/OPAL
  - FY 01 MightySatII.1
- Identified commercial technology transfer opportunities
- FY03 Approved for four pre-flights on Space Shuttle - the first launch is on STS-113
- FY07 Final MEPSI flight manifested on STPSat-1